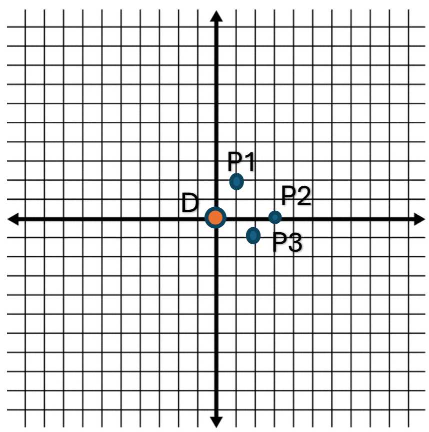
Example Case: Short Route Optimization

Problem
Assume you have a Depot (D), and must visit three pickup points (P1, P2, P3) and return to the Depot. Coordinates on a simple grid:

- Depot D = (0, 0)
- P1 = (1, 2)
- P2 = (3, 1)
- P3 = (2, -1)



Distance metric: use **Euclidean distance** (straight-line). Find the visiting order (D → ? → ? → ? → D) that gives the **shortest total distance**. Show your calculations and the best route.

1. Compute pairwise distances (round to 2 decimals):
   - d(D,P1) = _____
   - d(D,P2) = _____
   - d(D,P3) = _____
   - d(P1,P2) = _____
   - d(P1,P3) = _____
   - d(P2,P3) = _____
2. List all possible visiting orders (6 permutations) and compute total distance for each (Depot→A→B→C→Depot). Mark the smallest.

Step-by-step solution:

Compute Euclidean distance d((x1,y1),(x2,y2))=$\sqrt{(x2-x1)^2+(y2-y1)^2}$

1. d(D,P1): D(0,0), P1(1,2)
   - $\Delta x = 1 - 0 = 1$
   - $\Delta y = 2 - 0 = 2$
   - $\Delta x^2 = 1 \times 1 = 1$
   - $\Delta y^2 = 2 \times 2 = 4$

  - sum = 1 + 4 = 5
  - sqrt(5) ≈ 2.2360679 → round to 2.24
    => d(D,P1) = **2.24**
2. d(D,P2): D(0,0), P2(3,1)
   - Δx = 3
   - Δy = 1
   - $Δx^2$ = 9
   - $Δy^2$ = 1
   - sum = 9 + 1 = 10
   - sqrt(10) ≈ 3.16227766 → **3.16**
     => d(D,P2) = **3.16**
3. d(D,P3): D(0,0), P3(2,-1)
   - Δx = 2
   - Δy = −1
   - $Δx^2$ = 4
   - $Δy^2$ = 1
   - sum = 4 + 1 = 5
   - sqrt(5) ≈ 2.2360679 → **2.24**
     => d(D,P3) = **2.24**
4. d(P1,P2): P1(1,2), P2(3,1)
   - Δx = 3 − 1 = 2
   - Δy = 1 − 2 = −1
   - $Δx^2$ = 4
   - $Δy^2$ = 1
   - sum = 4 + 1 = 5
   - sqrt(5) ≈ 2.2360679 → **2.24**
     => d(P1,P2) = **2.24**
5. d(P1,P3): P1(1,2), P3(2,−1)
   - Δx = 2 − 1 = 1
   - Δy = −1 − 2 = −3
   - $Δx^2$ = 1
   - $Δy^2$ = 9
   - sum = 1 + 9 = 10
   - sqrt(10) ≈ 3.16227766 → **3.16**
     => d(P1,P3) = **3.16**
6. d(P2,P3): P2(3,1), P3(2,−1)
   - Δx = 2 − 3 = −1
   - Δy = −1 − 1 = −2
   - $Δx^2$ = 1
   - $Δy^2$ = 4
   - sum = 1 + 4 = 5
   - sqrt(5) ≈ 2.2360679 → **2.24**
     => d(P2,P3) = **2.24**

Now list the 6 permutations (Depot → A → B → C → Depot) and compute totals. Use the computed pairwise distances above. We'll round totals to 2 decimals.

Permutation 1: D → P1 → P2 → P3 → D

- d(D,P1) + d(P1,P2) + d(P2,P3) + d(P3,D)
- = 2.24 + 2.24 + 2.24 + 2.24
- Sum stepwise: 2.24 + 2.24 = 4.48; 4.48 + 2.24 = 6.72; 6.72 + 2.24 = 8.96
- Total = **8.96**

Permutation 2: D → P1 → P3 → P2 → D

- d(D,P1) + d(P1,P3) + d(P3,P2) + d(P2,D)
- = 2.24 + 3.16 + 2.24 + 3.16
- Sum: 2.24 + 3.16 = 5.40; 5.40 + 2.24 = 7.64; 7.64 + 3.16 = 10.80
- Total = **10.80**

Permutation 3: D → P2 → P1 → P3 → D

- d(D,P2) + d(P2,P1) + d(P1,P3) + d(P3,D)
- = 3.16 + 2.24 + 3.16 + 2.24
- Sum: 3.16 + 2.24 = 5.40; 5.40 + 3.16 = 8.56; 8.56 + 2.24 = 10.80
- Total = **10.80**

Permutation 4: D → P2 → P3 → P1 → D

- d(D,P2) + d(P2,P3) + d(P3,P1) + d(P1,D)
- = 3.16 + 2.24 + 3.16 + 2.24
- (same numbers as Perm 3) → Total = **10.80**

Permutation 5: D → P3 → P1 → P2 → D

- d(D,P3) + d(P3,P1) + d(P1,P2) + d(P2,D)
- = 2.24 + 3.16 + 2.24 + 3.16
- (same as Perm 2) → Total = **10.80**

Permutation 6: D → P3 → P2 → P1 → D

- d(D,P3) + d(P3,P2) + d(P2,P1) + d(P1,D)
- = 2.24 + 2.24 + 2.24 + 2.24
- = 8.96 (same as Perm 1)
- Total = **8.96**

Best routes: Permutation 1 and 6 tie for shortest at **8.96 units**. Example shortest visiting order:

- D → P1 → P2 → P3 → D (or D → P3 → P2 → P1 → D)